Simulation for a BSO crystal array in Geant4

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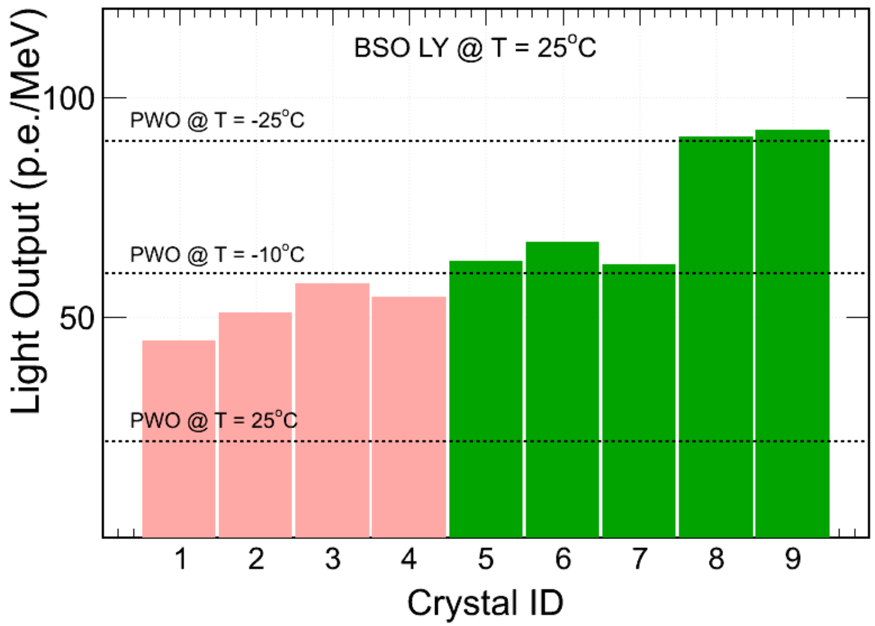
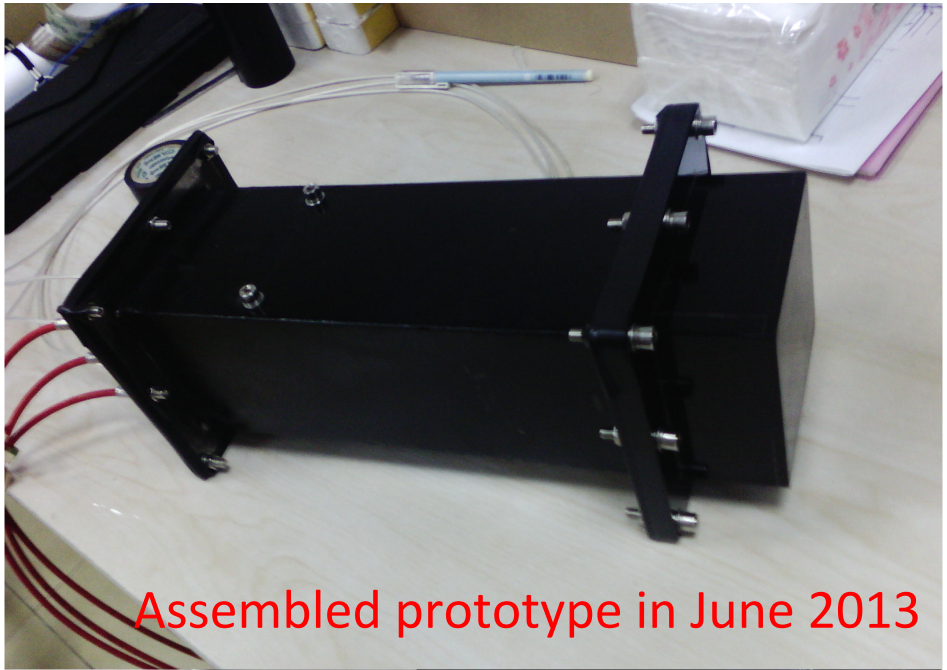
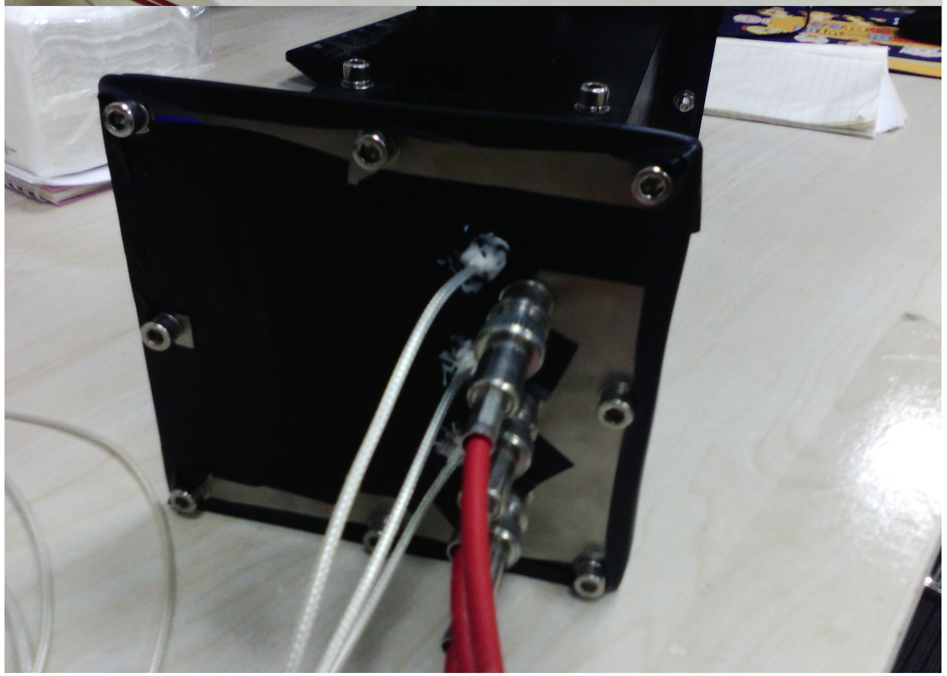
A 3x3 prototype



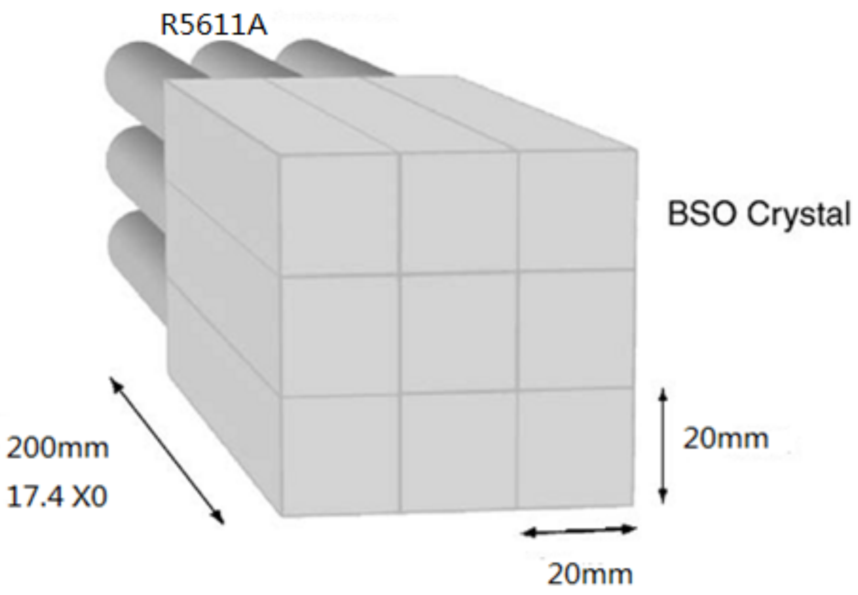


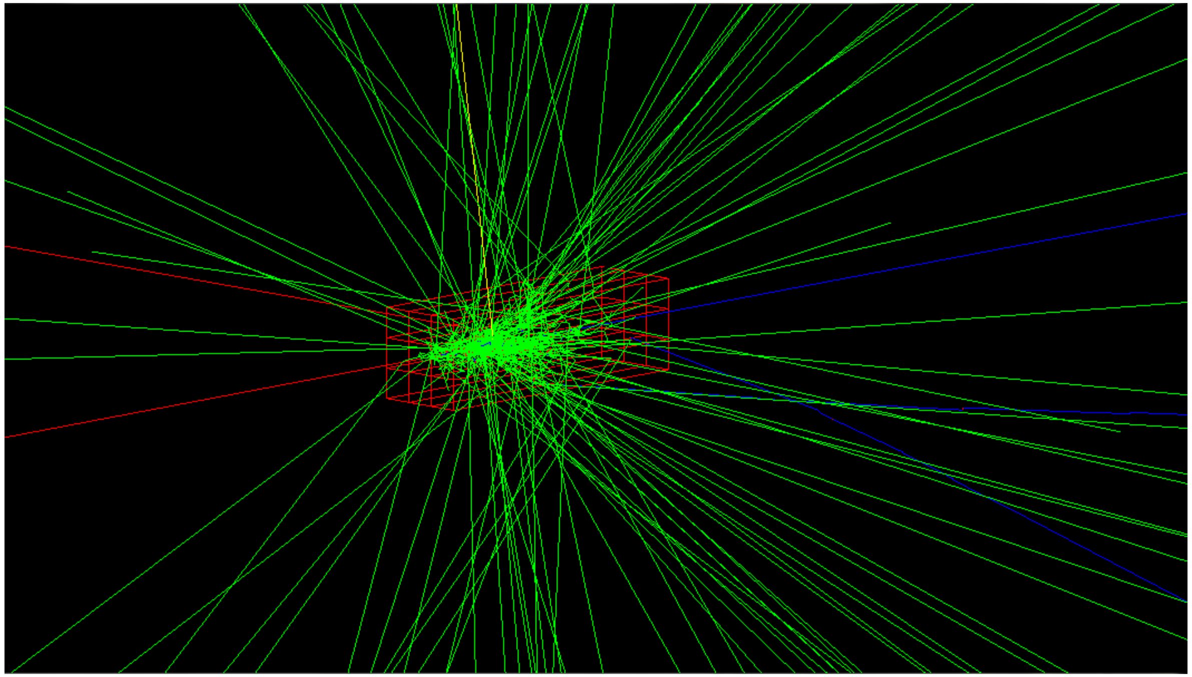


The 9 BSO crystals from SICCAS last year are tested in USTC and CalTech (#5 and #9 for radiation test).

The two crystals #8 and #9 reach the LO of PWO under T=-25°C and with very good uniformity.
The production technique is developing, now SICCAS can keep the performance of as #9.

Geometry in Geant4



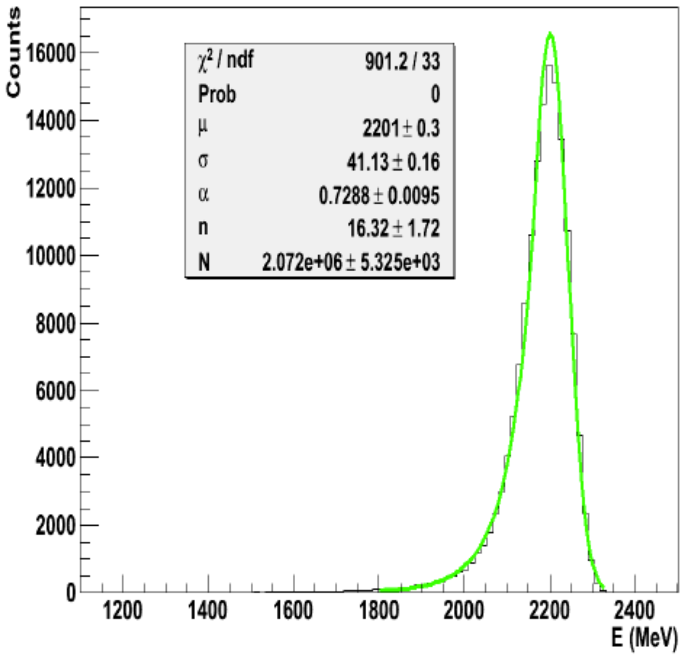


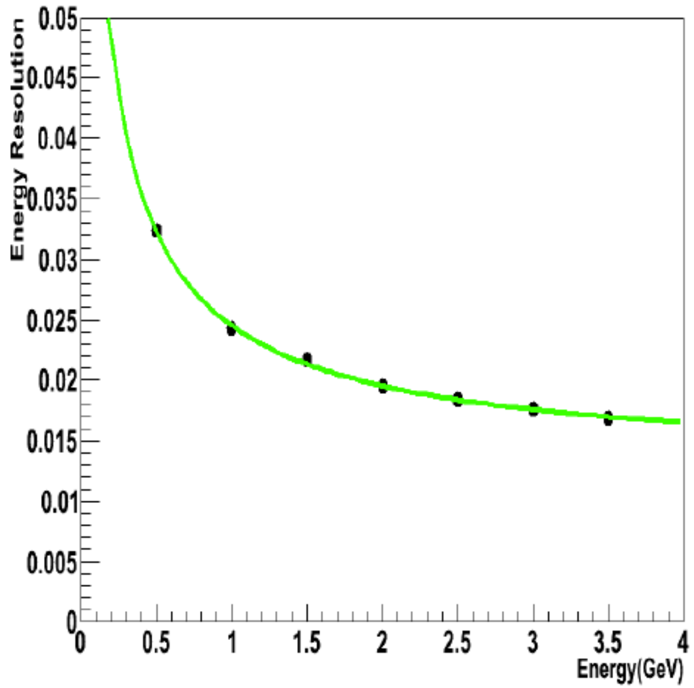
An ideal geometry of 3×3 BSO calorimeter was designed in GEANT4, with the size of 20×20×200 mm for each crystal.

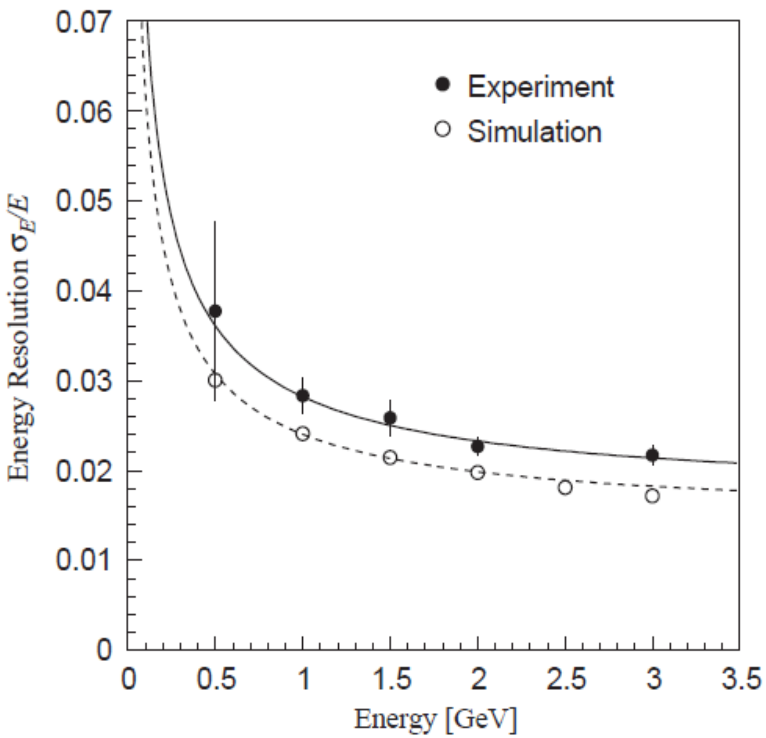
The electron beam interacts with the crystals.

The incident electron energies were scanned from 0.5 – 3.5 GeV

Energy resolution







2-3 GeV electron -> 2-3% energy resolution.

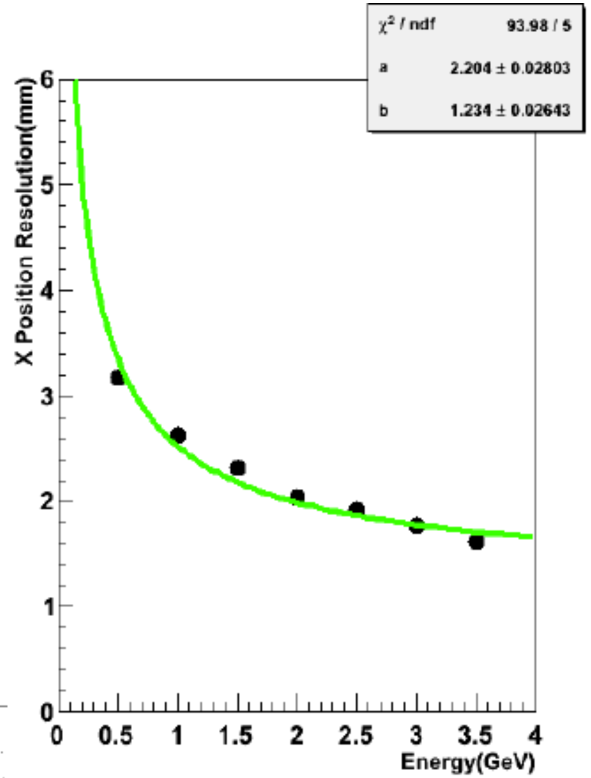
Our result is consistent with
H. Shimizu, et al., NIM A**550** (2005) 258.

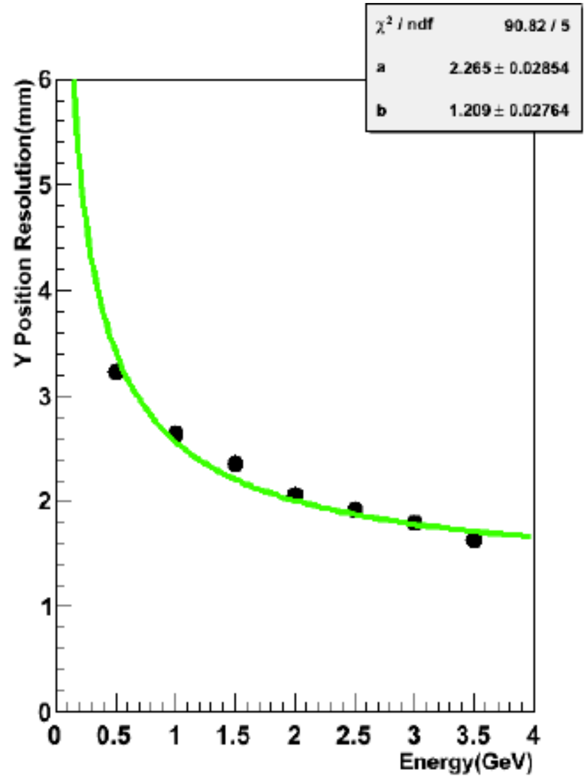
$$\frac{\sigma_E}{E} = (0.021 \pm \frac{0.000098}{\sqrt{E}})^2 + (0.013 \pm 0.000081)^2$$

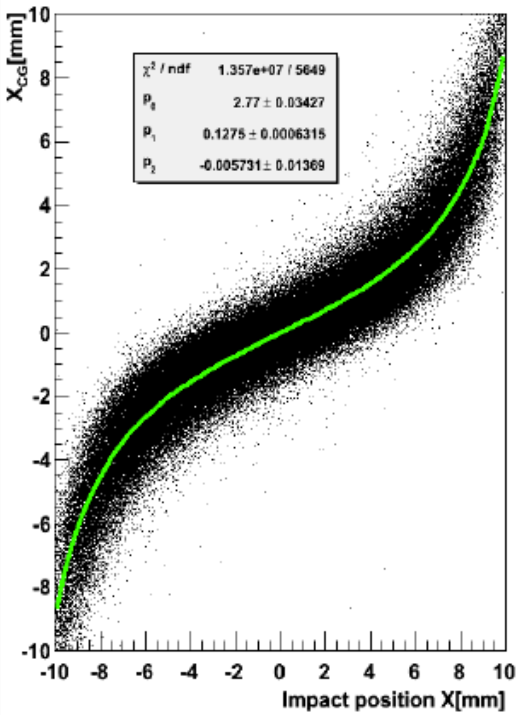
position resolution

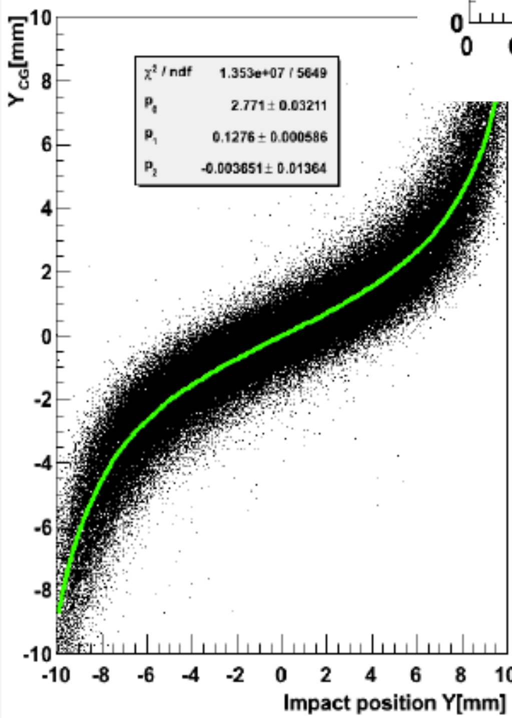
A center of gravity method was used

$$X_{CG} = \frac{\sum_{i=1}^{9} E_i x_i}{\sum_{i=1}^{9} E_i}$$









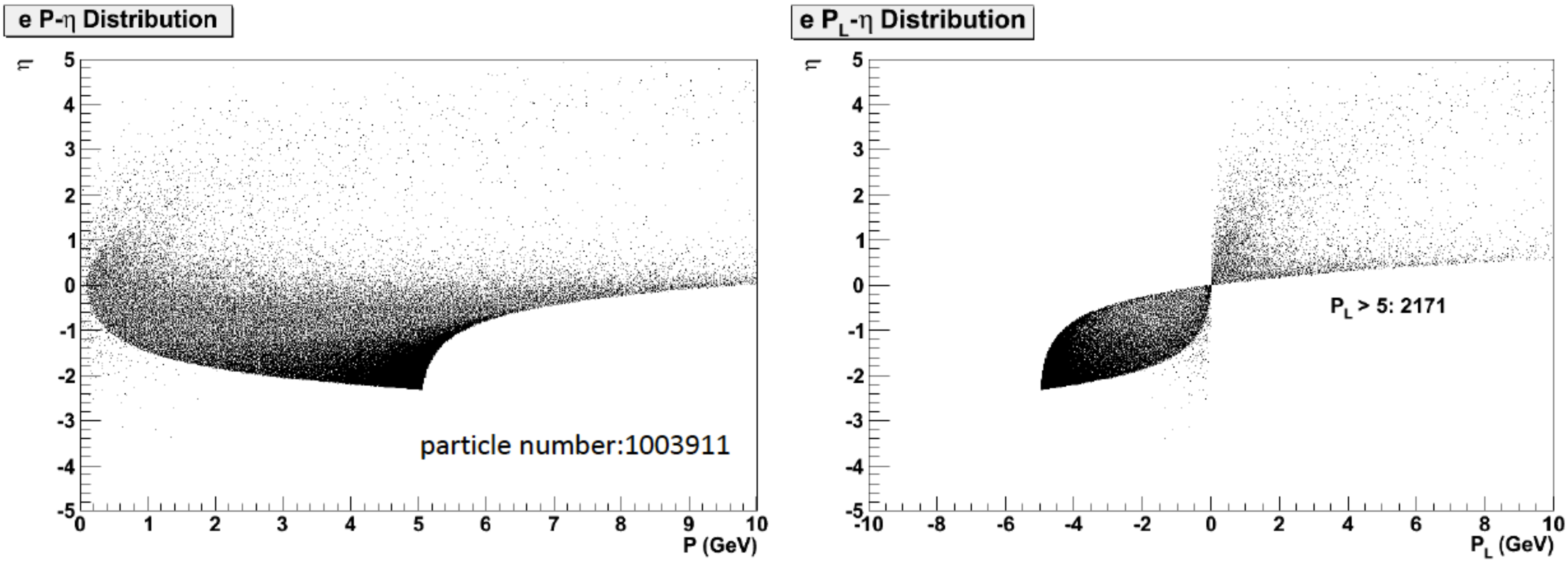
The position resolution is better than 5mm for incident electron energy > 0.5 GeV and is better than 2mm for energy > 3 GeV.

Pythia + Geant4 simulation

To further study the particle identification capability of the BSO calorimeter, a 5×5 geometry was used in GEANT4.

The input particles were generated in PYTHIA with e+p at 5+250 GeV collisions.

Q^2 was required larger than 1.



The phase space of the electrons generated from PYTHIA.

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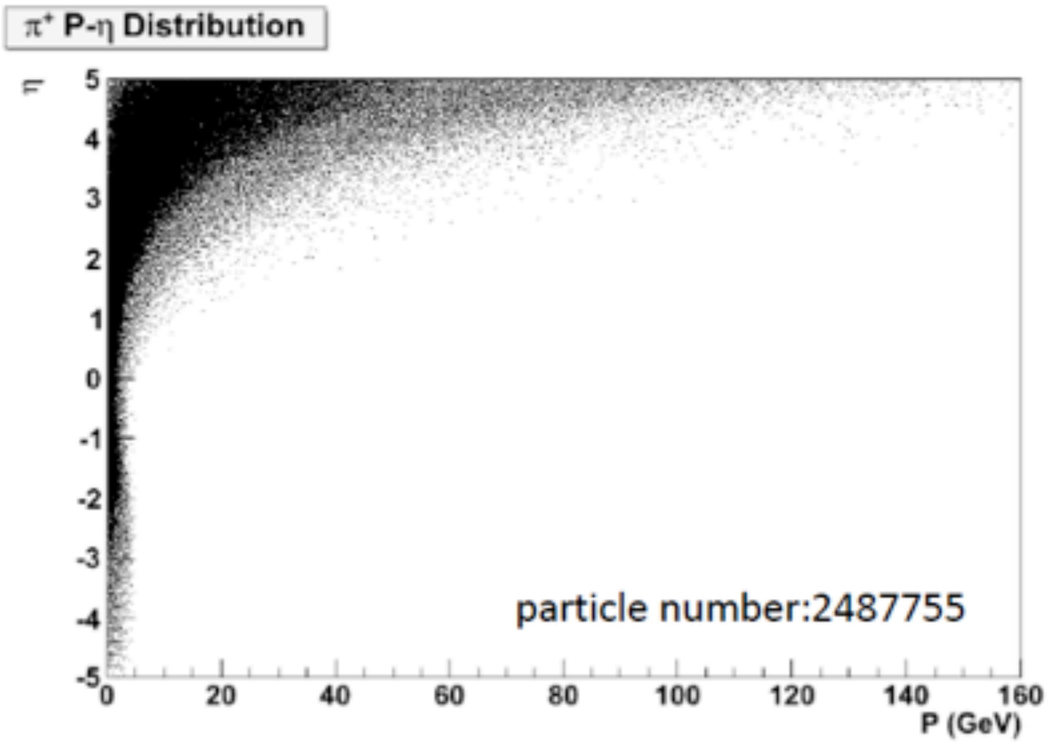
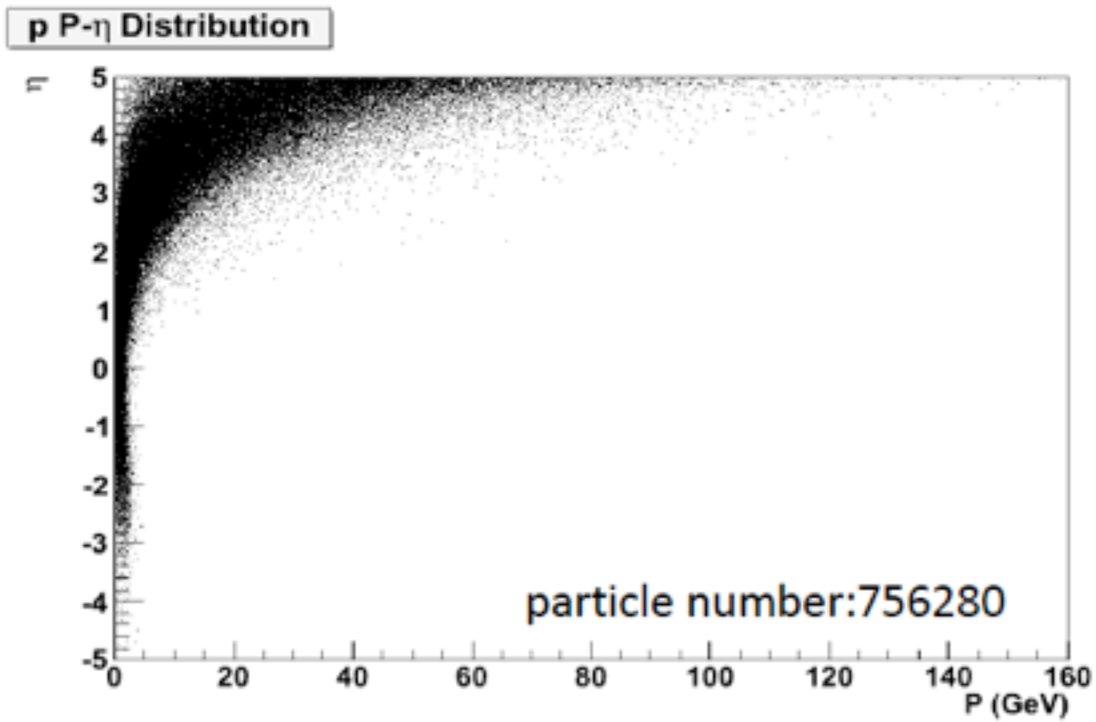
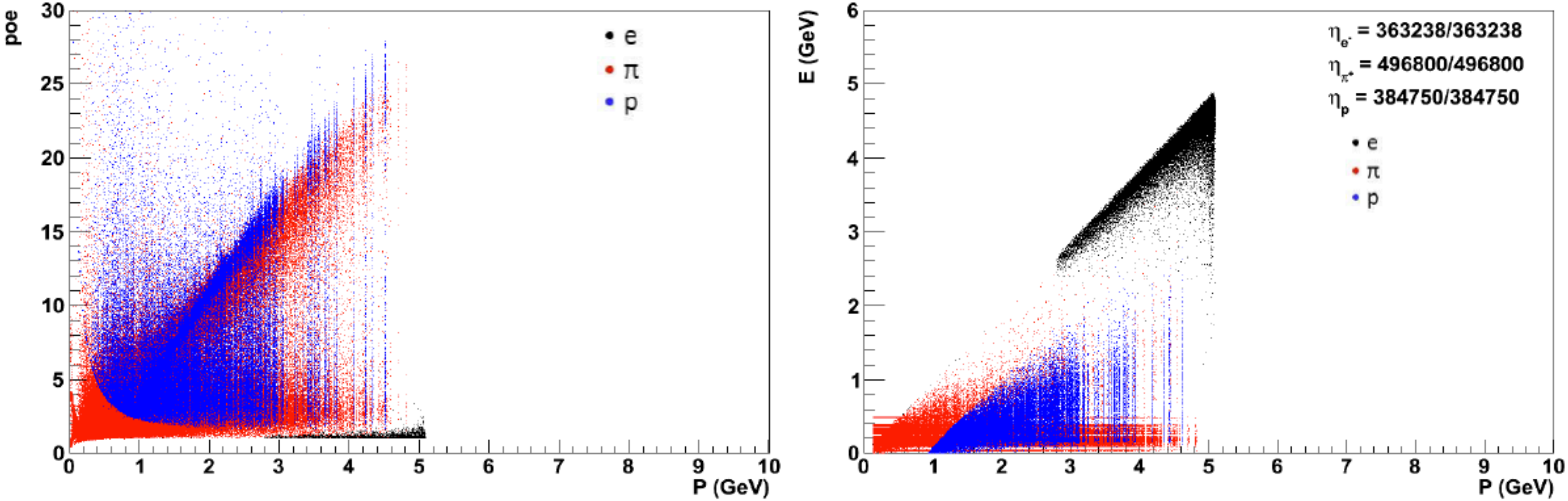




The phase space of the pions (left) and protons (right) generated from PYTHIA.

Particle ID performance

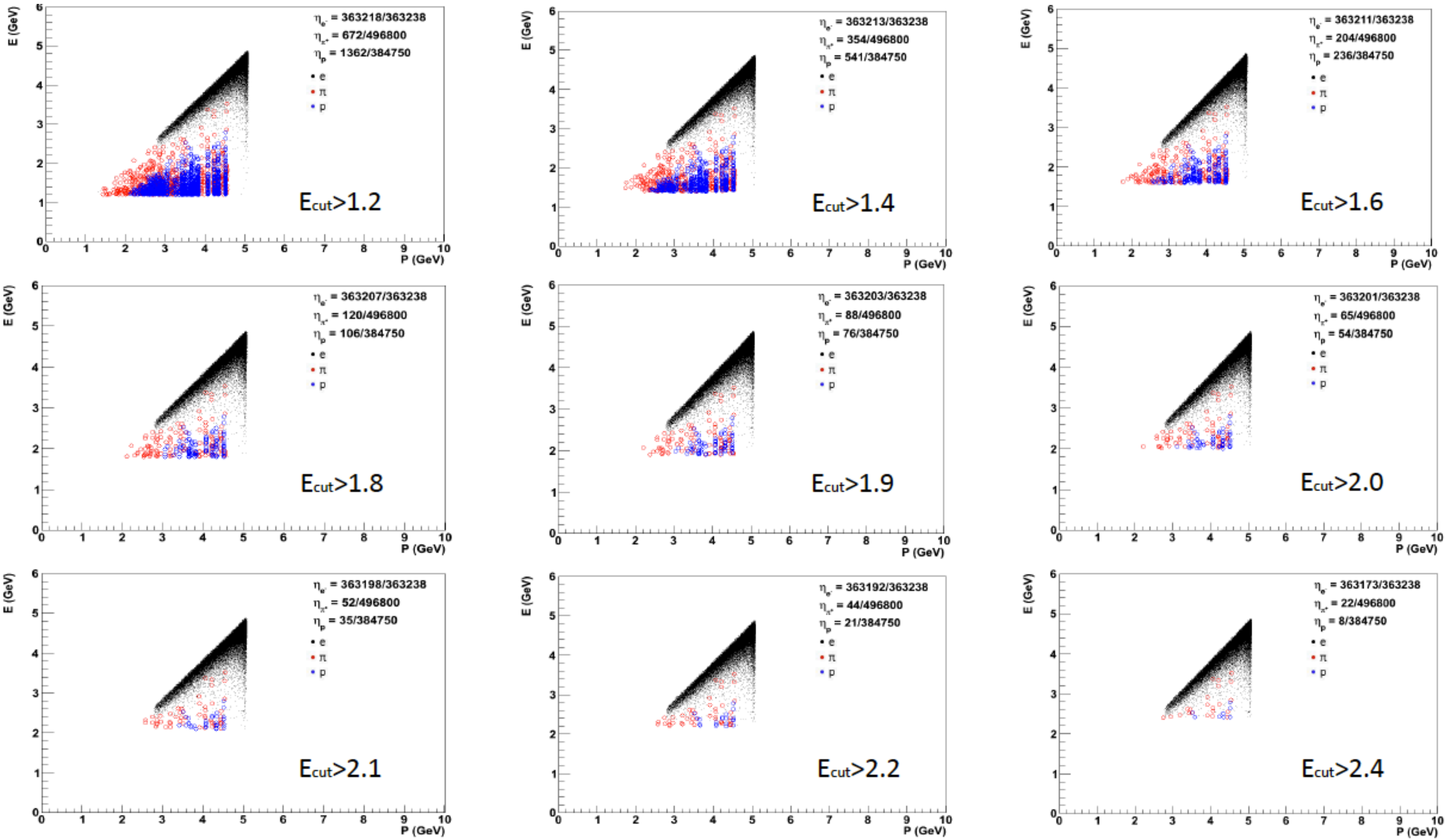


Particles are required to incident in the BSO crystals within -4 < η < -2.

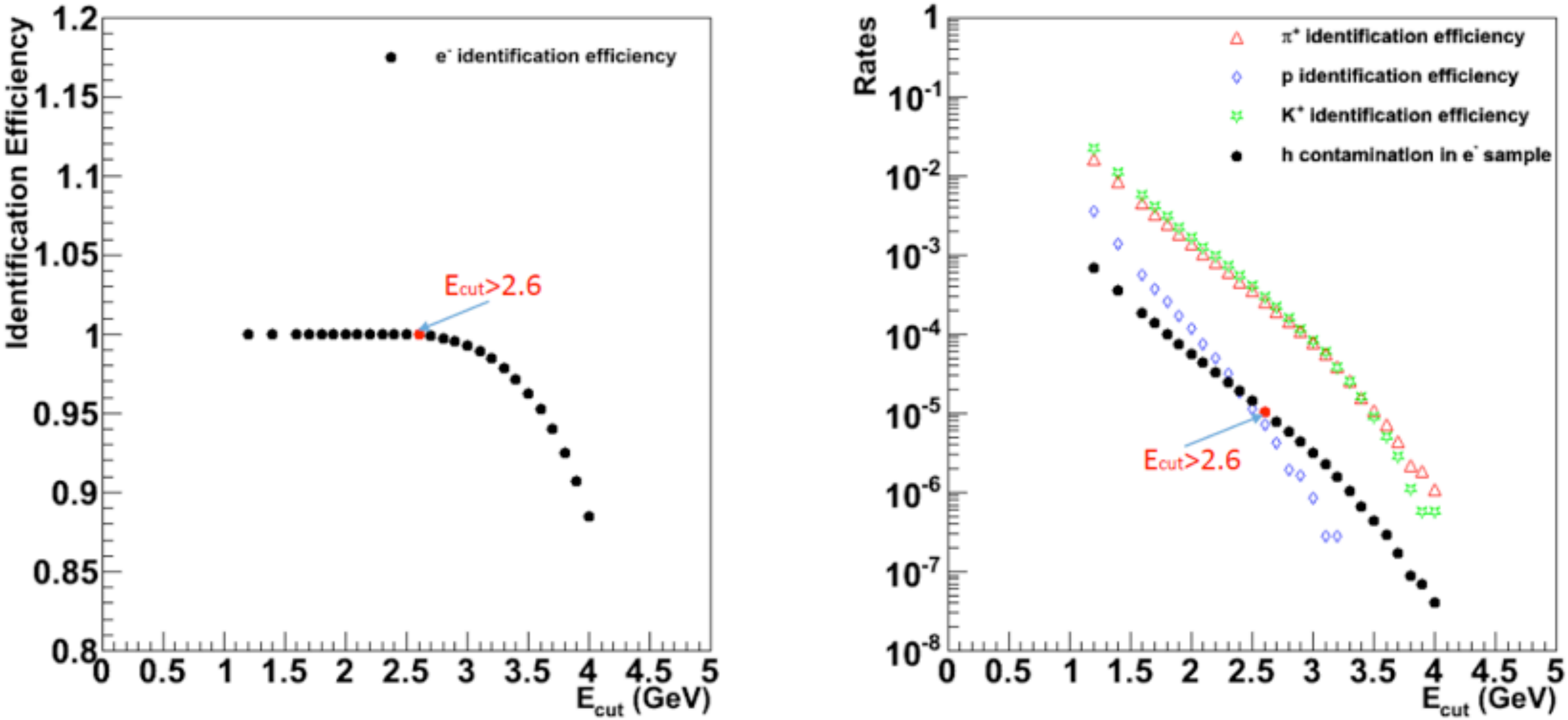
Left: p/E as a function of momentum.

Right: Deposit energy as a function of momentum.

Particle ID performance

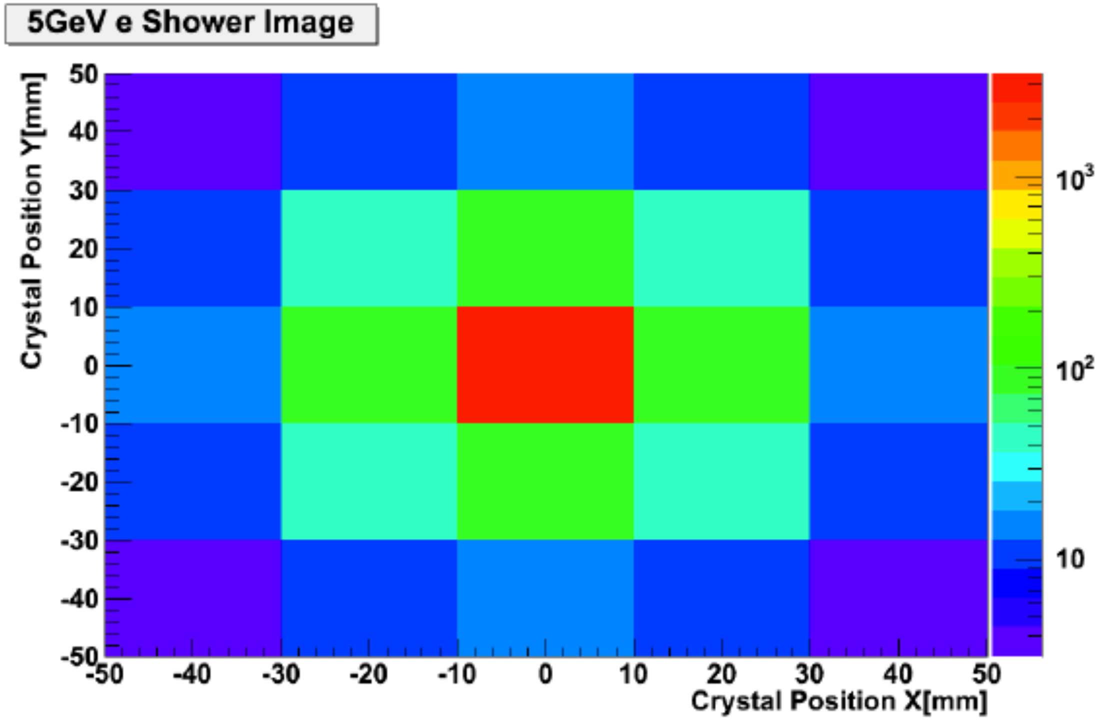


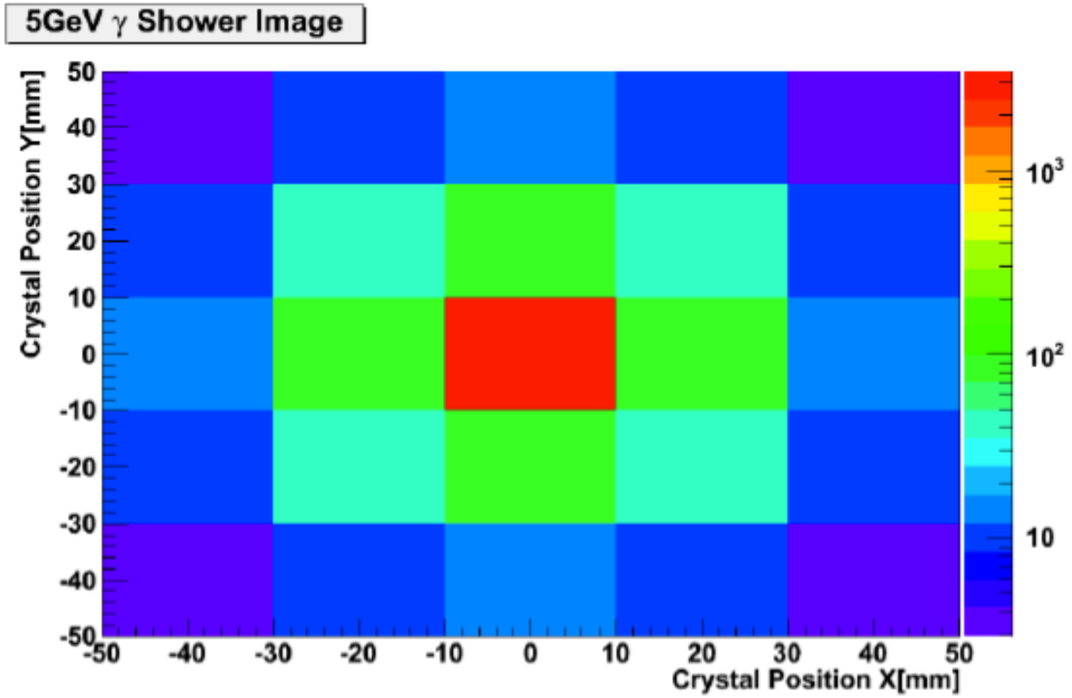
Particle ID efficiency



With Ecut > 2.6 GeV, the hadron contamination is around 10-5, hadron rejection power > 99.9%.

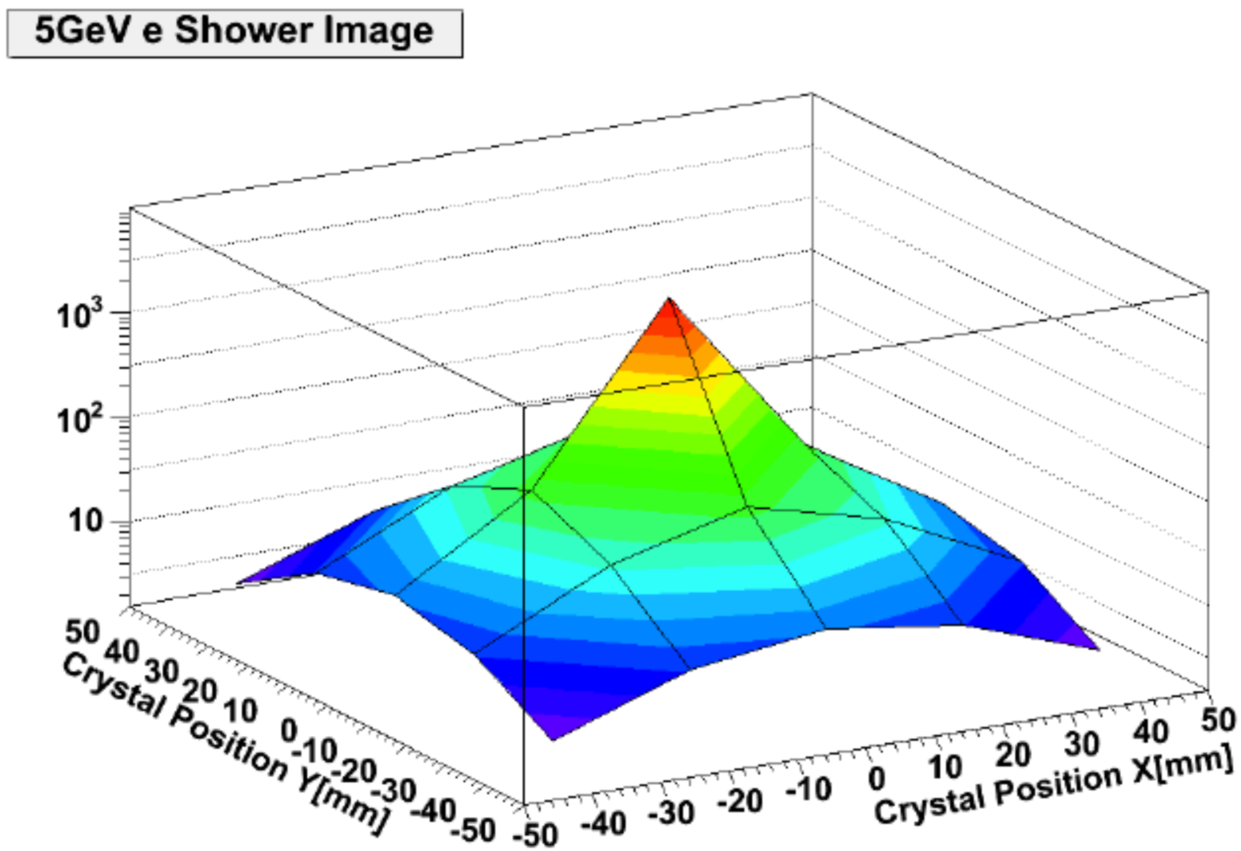
Energy shower image





Incident from the center of the 5x5 crystal array.
X-Y energy deposits in the crystal array.
Very similar for electron and photon.

Energy shower image



3D energy deposits in the crystal array.
Very similar for electron and photon.

What is on going?

- ✧ Simulation with different collision energies.
- ✧ Adding dead area to test the efficiency.
- ✧ With larger size of the crystal array to test the shower images.
- ✧ Plan to have beam test this October in CERN with 1 - 10 GeV electron beam.